ELECTRON-IMPACT-INDUCED EMISSION CROSS SECTIONS OF NEON IN THE EXTREME ULTRAVIOLET

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ABSTRACT

We have measured the extreme ultraviolet (1 :UV) spectrum of neon produced by electron impact excitation. The measurements were obtained under optically thin conditions, and at a spectral resolution of 0.5 nm full width at half maximum (FWHM). The most prominent feature.s of the EUV spectrum between 45-80 nm are the resonance lines of Ne I at 73.6 and 74.4 nm and a multiplet of Ne II at 46.14 nm (the average value for the line center of the two closely spaced ion lines at 46.07 and 46.22 m). Absolute emission cross sections of these lines at 3(K) eV were measured and compared to other previous measurements. The measured emission cross section value.s at 300 eV for the Ne I line-s at **73.6** and *74.4* nm are found to be *5.32 x* 10^{-18} cm^2 *and* 1.2.1 x 10^{-18} cm^2 respectively, and for the Ne II multiplet at 46.14 nm is found to be 1.S3 x 10- I^8 cm^2 (sun-I of the 46.07 and 46.22 nm line cross sections) with an uncertainty of 4 1%. in addition, excitation functions were measure.d for the Ne 1 resonance lines (0-400 eV) and Ne 11 ion line (0- 1keV). The excitation functions for the Ne 1 resonance lines were corrected for polarization because these are strong] y polarized.

INTRODUCTION

Electron-impact-induced emission studies of Ne arc of considerable importance in understanding the basic physics of collisional excitation processes and in technological applications. From the basic physics point of view, Ne is a part of the rare-gas series, and like other ram-gas atom is of special interest because Nc has a large number of excited levels. Also, the simple LS and jj coupling schemes arc. not strictly applicable for neon (Chan et al., 1992). The LS coupling breaks-clown and changes into jl coupling and then to jj coupling in the spectroscopic description of the states of this atomic system (Machado c1 al., 1984). From the applied physics point of view, Nc plays an important role in many discharge systems such as Ne-discharge light sources, He-Ne lasers, and Ne-Xe-NF_2 lam-s (Nighan, 1981; Huentis et al., 1978). Knowledge of the excitation cross sections is therefore essential for modeling these discharge. systems (Phillips et al., 1985). Neon also plays an important role in astrophysics since it is the most abundant of the rare gases in the solar system, and in the cosmos after helium. Its spectroscopic detection in the atmospheres of the outer planets, which are expected to reflect solar abundance, has eluded astronomers (Atreya, 1986). 1 lowever, the recent astrophysical discovery of hot neon nova has occurred because of the rich spectra from highly ionized lines of neon (Barger et al., 1993). At low temperatures, the importance of EUV spectra of neutral neon and its singl y and doubl y charged ions from cool stcl lar atmospheres have been considered by Landini et al., (1985). '1'heir models of EUV sul-face fluxes of stellar objects arc limited by accurate knowledge of plasma emissivities. The main problem in the calculation of the plasma emissivity is the unavailability of accurate excitation cross sections for electron impact. A need for the measurement of electron im pact excitation cross sections for Nc in modeling astrophysical plasmas is pointed out by Shull (1993).

in this paper, the electron-impact-induced emission spectrum of Ne corresponding to the resonance transitions in the EUV spectral region from 45-80 nm at 300 eV impact energy is reported. (In a companion paper we have reported emission moss sections of Ne 11 and Nc 111 excited by electron impact, measured in the far ultraviolet (FUV) spectral region from 120-270 nm (James et al., 1995)). Absolute emission cross sections corresponding to the Ne spectral feature.s (Ne 1, Ne II and Nc III) in the 45-80 nm region were measured. Previous work concerning electron-impact excitation of Ne in the 45-80 nm wavelength region is reviewed and a comparison of our results for absolute emission cross sections of Nc emission feature.s (resonance and ion lines) with those of the previous work is given. Ne, like other heavier noble gases, provides important resonance lines of the type $np^5(n+1)s \rightarrow np^6$, and ion lines of the type $nsnp^6 \rightarrow ns^2np^5$. The 73.59 nm arid 74.37 nm resonance lines of Ne 1 and 46.07nm and 46.24 nm resonance lines of Ne II represent the transitions between the lowest lying electronic excited states and the ground state of the atom and ion, respectively. Optical excitation functions were also measured for the Ne 1 (73.59 nm) $2p^5[^2P_{1/2}]3s(1\ 1'])$-+ $2p^6(^1S_0)$ arid Nc 1 (74.37 nm) $2p^5[^2P_{3/2}]3s(^3P_1)$- › $2p^6(^1$ So) resonance transitions which have predominantly singlet and triplet characters, respectively. In addition, the optical excitation function for the unresolved multiplet of Nc 11 (46.07 + 46.22 run) $2s(^2S_{1/2})2p^6 \rightarrow 2s(^2P_{3/2,1/2})2p^5$ transition, which results from the removal of a 2s electron and subsequent decay to the ion ground state, was measured.

The ground level of Nc is $1\ s^22s^22p^6\ ^1S_0$. The lowest excited configuration is $1\ s^22s^22p^53s$, which yields four energy levels. These levels arc $1s_2, 1s_3, 1s_4$ arid $1s_5$ in Paschen notation (Register et al., 1984). The $1s_3$ and $1s_5$ levels are metastable with very long radiative lifetimes. Electron impact induced emission resulting from radiative. decay from these levels to the ground stale, therefore, cannot be measured by conventional optical methods. The 1 s2 level is primarily $^1P_1$ in character, with less than 10% admixture

of $^3P_1$, and vice versa for the $1s_4$ level (Phillips et al., 1985). The transitions from these levels (1 s2 and 1 s4) to the ground state represent the strongest resonance transitions in the vacuum ultraviolet (VUV), and occur at 73.6 and 74.4 nm, respectively. Direct cascade to these resonance levels comes from the $2p^53p$ group ($2p_1$-$2p_{10}$ in Paschen notation). Fig. 1 shows a simplified level diagram for (he Nc I 73.6 and 74.4 nm resonance transitions and for the Ne II 46.1 and 46.2 nm transitions.

The two most recent surveys of electron-impact-induced emission cross section and optical excitation function measurements for the resonance transitions for Nc have been published by van der Burgt et al, (1989) and by 1 leddle and Gallagher (1989) for the extreme ultraviolet (1 3U V) spectral region. Earl y measurements included those of 1 lertz (1969) who reported the Ne 1 (73.6, 74.4 nm) optical excitation functions, and those of de Jongh (1971) who measured the polarization-free optical excitation function for the, Nc 1 (73.6 nm) resonance transition. Later, Luyken et al. (1972) and van Raan et al. (1973) reported cross sections for the Ne II (46.1 -t 46.2 nm) ion lines. Tan et al. (1974) measured the Ne I (73.6 nm) photoemission cross section, normalized to an average of experimental value.s for the oscillator strengths for this transition. Zapesochnyi et al. (1974) reported optical excitation functions for the Nc 11 (46. 1 + 46.2 nm) transitions. They normalized their cross sections based upon the first Born approximation. Papp et al. (1977) measured optical excitation functions for the Ne 111 (37.9, 49.0 nm) transitions. 1)ijkkamp and de Heer (1981) reanal yzed the Nc II (46.1 + 46.2. nm) cross section from Luyken et al. (1972). They put the cross section on an absolute scale using the Bethe approximation (Bethe, 1930), which led to a cross section 3.7 times smaller than that obtained based on a normalization utilizing the van Raan's result (1 973). Eckhardt and Schartner (1983) reported photoemission cross sections for the Nc II (46.1 + 46.2 nm) and Nc III (49.() nm) cross sections. 'l-heir c10ss sections arc based on the Bethe approximation (Bethe, 1930), with experimental and theoretical values for the optical

oscillator strengths from Kim and Inokuti (1968) and de Jongh and van Eck (] 971). Phillips et al. (1985) measured the Ne 1 (73.6 and 74.4 nm) cross sections utilizing a laser-inducml fluorescence technique. They normalized to the Born approximation and determined the cascade contribution by direct measuren ient. Register et al. (1984) reported differential cross sections (1)CS's) for excitation of sixteen features in the electron energy-loss spectrum of Ne corresponding to individual level excitations (some unresolved). By integrating their measured DCS's, they obtained the integral cross sections for direct excitation without the cascade contribution which hampers the analysis of optical Nc data.

The neon optical emission and direct excitation cross sections for the resonance lines cannot be directly compared with each other on the basis of optical oscillator strength because the optical Nc data includes large cascade components to the measured line intensities. investigators (Tan cl al., 1974; Phillips et al., 1985) reported the existence of large, cascade components which contributed to the emission cross sections of the two resonance lines at 73.6 and 74.4 nm. "l-an et al. (1974) assumed that the cascade population of the Nc $^1P_1$ level at 73.59 nm varies with electron-impact energy as E^{-1}, whereas Phillips et al. (1985) determined the cascade population by direct measurement. Phillips et al. (1985) measured the emission cross sections of the two resonance lines at 3(KI eV electron-impact energy, resulting in a cascade contribution of 29%. For 40 cV, they estimated a total cascade contribution of *36%* for the 73.6 and 74.4 nm resonance lines.

EXPERIMENTAL PROCEDURE

The experimental apparatus, calibraton procedure, and cross-section measurement technique have been described in our earlier publications (Ajello et al., 1988; Ajello et al.,

1989; Kanik et al.,] 995). The medium-resolution 1.()-m spectrometer system was used in the present measurements. It consists of an electron-impact collision chamber in tandem with a UV spectrometer. The EUV emission spectrum of Nc was measured by crossing a magnetically collimated beam of electrons with a beam of Nc gas formed by a capillary array. 1 :mitted photons, corresponding to radiative. decay of collisionally excited states of Ne, were detected at 90° by the UV spectrometer c-quipped with a channeltron detector. The resulting emission spectrum, measured at 300 eV incident electron beam energy, was calibrated for wavelength from 45 to 80 nm according to the procedures described by Ajello et al. (1989). The laboratory measurements, together with the spectroscopic models, permitted the EUV spectrum from 112 Rydberg series to serve as a relative calibration standard in the 80-2.30 nm range. For shorter wavelengths (40-80 nm) the n 1p0 n=2, 3, *4* Rydberg series of He and Ar 1 and Ar 11 multiplets were used as the calibration source. in order to determine [he. absolute, value of the emission cross section corresponding to each measured feature, onc additional procedure (normalization) must be applied. The determination of the absolute emission cross sections for Nc was achieved by admitting a research grade gas mixture (purchased from a commercial source) containing 50% Nc and 50% N2 into the scattering chamber and measuring the fluorescence signal from the gas mixture (Nc+ N_2). Static gas (Nc+ N2) mode was utilized for the measurements to maintain the same number density for Nc and N_2 in the target region. Accuracy of the gas mixture is 99.995% as stated by the manufacturer. The relative cross sections for each feature were obtained by integrating the signal intensity over the wavelength interval for the feature of interest, and by then comparing the integrated signal intensity for each Nc spectral feature to that of the N2 $c_4'^1\Sigma_u^+(0,0)$ 95.8 nm fluorescence signal at 300 eV electron impact energy. The absolute cross section of the 95.8 nm spectral feature of N_2, at 3(K) CV impact energy (Ajello et al., 1989) was then used to normalize the relative intensities of the Ne spectral features. A background gas pressure about 1.0×10^{-6} Torr was used to avoid the effect of self absorption on the Ne resonance

lines as discussed below. It should be pointed out here that the Ne background gas pressure was measured by an ion gauge and the ion gauge readings were corrected for the relative sensitivity of ion gauge response data for Nc (Bartmess and georgiadis, 1983).

The background gas pressure for the present determination of Nc emission cross sections was carefully chosen to ensure optically thin conditions and to avoid self-absorption effects, particularly for the Ne 1 resonance lines at 73.59 and 74.37 nm. The following approach has been employed to determine the maximum background gas pressure that can be used while maintaining optically thin conditions. The relative intensities of the Ne] resonance line (73.59 nm) and the Nc 11 ion line (46.1 + 46.2. nm) have been measured as a function of pressure over the range 3 x 10-7 to 2 x 10^{-4} Torr. The Ne II line is not expected to exhibit any optical depth effects in this pressure range and therefore acts as a normal ization feature. The experimentall y determ ined intensity ratio of these features is shown in Fig, 2, and is approximately constant up to a background gas pressure of 5 x 10^{-6} Torr where it begins to decrease. This indicates the onset of self-absorption at 73.59 nm. The measurement can be verified by calculating the pressure fOr optical depth unity at line Center fOr the strongest resonance line (Nc I at 73.6 rim). The optical depth, τ_0, at line center is given by

$$\tau_0 = \sigma_0 nl \qquad (1)$$

where σ_0 is the absorption cross section at line center, n is the number density of the absorbing gas, and 1 is the path length (16.83 cm) from the collision volume to the spectrometer entrance slit. The absorption cross section value of 3.529 x 10-] ^{3} cm^2 at line center, determined by using the oscillator strength (0.1 59) for the Ne I 73.6 nm resonance transition at 300 K (Chan et al., 1992), is used to obtain the pressure corresponding to optical depth unity at line center. The value of the pressure is found to

be 5.2 x] 0^{-6} Torr, which supports our experimental determination for the onset of self absorption of the Ne I 73.6 nm resonance line (Fig. 2).

The measurements reported here were obtained at an angle of 90° between electron beam axis and optic axis. 'he Ne 11 resonance lines ($^2S_{1/2} \rightarrow {}^2P_{1/2,3/2}$) arc unpolarized and unaffacted by self absorption. However, the Ne 1 resonance lines (1P] -> $^1S_0$ and $^3P_1 \rightarrow {}^1S_0$) are strongly polarized, as measured in the E_T - 480 eV energy range (where E_T indicates the threshold energy) by Hammond et al. (1989). The polarization was measured to be zero at 300 cV. For this reason, wc studied the electron-impact-induced fluorescence spectrum of Nc at 300 cV. Wc measured the polarization-free optical excitation function of the Ne II (46.] + 46.2 nm) line.s from 0-1keV. "l'he excitation functions for the strongly polarized Nc 1 (73.69 nm and 74.37 nm) lines were also measured in the 0-400 eV impact energy range, and these were corrected for polarization based on the Hammond et al. (1989) polarization data.

RESULTS AND DISCUSSION

The EUV spectrum

Fig. 3 shows the Ne laboratory emission spectrum in the EUV spectral region at 300 CV electron-impact energy in the wavelentgth range of 45-80 nm. The spectrum was obtained at a gas temperature of 3000 K, under optically thin conditions, at a spectral resolution of 0.5 nm FWI IM, and calibrated for wavelength. The background pressure was 5x10-^{7}Torr. The emission spectrum of Nc consists of eight spectral features. Table 1 lists the candidate, identifications and the measured absolute emission cross sections corresponding to Nc 1, II and 111 transitions at 300 eV electron-impact energy. The identifications were taken from Kell y (1987).

The Ne I (73.6 nm) resonance transition represents the. strongest feature in the Ne EUV spectrum at 300 eV electron-impact energy. A comparison of the Ne I (73.6 nm) absolute emission cross section values indicate.f good agreement between the present determination and those of Tan et al. (1974) and Phillips et al. (1985). 'l-hc present result is about 17% higher than that of Tan et al. (1974) and about 18% lower than that of Phillips et al. (1985). Phillips et al.(1985) reported that the.ir measurements showed no dependence of the shape of the excitation functions on pressure. They used a higher gas pressure in their measurements than that used by Hertz (1969). Hertz (1969) obtained his cross section value for the Nc I (73.6 nm) resonance transition for two different pressures (P_1=2.7 x 10^{-3} Torr and P_2=0.3-0.8 x 10-4 "1'err). He reported that his cross section measurement showed a strong dependence on gas pressure due to the radiation trapping, and is about 1.'7 to 2.4 times higher than the present result, depending on pressure.

The Nc I (74.4 nm) resonance. transition represents the second strongest feature in the Nc EUV spectrum at 300 eV electron-impact energy. The present determination for the Nc 1 (74.4 nm) absolute emission cross section and that of Phillips et al. (1985) agree fairly well. "1'heir result is about 25% higher than ours. The present result is in excellent agreement with that of 1 lertz (1969) (disagreement is less than 1 %). It is not clear to us why there is a very large discrepancy between our result and that of Hertz (1969) for the Nc 1 (73.6 nm) absolute emission cross section since the agreement between the two cross section measurements for the Nc I (74.4 nm) is found to be excellent.

The root-sum-square uncertainty in the absolute cross sections in this work is estimated as follows: 1) uncertainty of 35% in the relative calibration, 2) uncertainty of 22% in the N2 (95.8 nm) emission cross section (Ajello et al. 1989) and 3) signal statistics uncertainty of 3%. Thus the overall error (square root of the sum of the squares

of the contributing errors) in the present cress section measurements is estimated to be about **4170.**

Excitation Functions

a. Ne I (73.6 and 74.4 nm) Resonance Lines

We show in Figs. **4** and 5 the excitation functions of Ne I 73.6 and 74.4 nm resonance transitions over the electron-irnpact energy ranges 0-400 eV. The excitation functions were corrected for polarization by usc of the following formula (van dcr Burgt et al., 1989):

$$\sigma_{ij}(E_0) = \frac{C[1 - P(E_0)/3]}{1 - P(E_0)\cos^2\theta} I(\theta), \qquad (2)$$

where $\sigma_{ij}(E_0)$ is the photoemission cross section at an electron impact energy (E_0), $P(E_0)$ is the polarization, $I(\theta)$ is the intensity of the emitted radiation at some angle, θ, (where θ = 90° in our experimental set up) and C is a constant related to the electron beam current, number density of the target gas and the path length of the electron beam through the target. The polarization of radiation, $P(E_0)$, for each electron-itnpact energy was tabulated by 1 Iammond et al. (1989) in the energy range from threshold to 500 eV. They measured VUV polarization which represents the integrated radiation emitted following electron-impact excitation of He and Nc. Wc used their values to correct our measurements for polarization.

Fig. 6 compares the present measurements of the Ne (73.6 nm) optical excitation cross sections with those of Phillips et al. (1985), 1 Iertz (1969), de Jongh (1971) and Tan et al. (1974). All those measurements and ours include the cascade contributions from the, upper levels. integral cross sections for dire.c[excitation (excluding cascade) reported by

Register et al. (1984) are also shown for comparison. Our results are in good agreement with those of Tan et al. (1974) at all energies and with that of de Jongh (1971) at 200 eV. Both sets of results are lower in value than the present ones but lie well between the error limits of the present measurements as shown in Fig. 6. The cross sections of Phillips et al. (1985) are higher than ours in the 40-300 eV energy range and the shape of their excitation function is different than ours. The discrepancy between the two data sets is worse in the peak region, and amounts to 70% at 40 eV. Measurements (with both low and high pressures) reported by Hertz (1969) are apparently too high. Direct excitation cross sections measured by Register et al. (1984) agree reasonably well with the present measurements and lie within the quoted error limits at all overlapping energies. Disagreement reaches up to 30% in the peak energy region.

The comparison of the present Ne (74.4 nm) optical excitation cross sections with those of Hertz (1969) and Phillips et al. (1985) is given in Fig. 7. All emission cross sections include a substantial amount of cascade contributions from the upper levels. This situation is worse for the 74.4 nm emission line (about 50% of the total cascade has an optically allowed character) than for the 73.6 nm line (van Raan, 1973). The Register et al. (1984) integral cross sections for direct electron-impact excitation are also shown in Fig. 7. The cross sections of Phillips et al. (1985) are much higher than ours (by up to a factor of 2) in the overlapping energy range. The disagreement between the two measurements is greater for Ne 1 (73.6nm) except that the shape of their excitation function is quite similar to ours. Measurements reported by Hertz (1969) agree well with ours in the higher energy region, but the agreement is much poorer in the peak region. The discrepancy between the direct excitation cross sections measured by Register et al. (1984) and the other measurements is quite large. This large discrepancy may be accounted for by large cascade contributions to emission cross sections from the upper levels. Direct excitation

cross sections of Register et al. (1984) do not contain any cascade components and they were expected to be lower than the emission cross sections.

b. Ne 11 (46.14) Multiplet

Fig. 8 shows the unresolved multiplet of Ne II polarizatio n-free excitation function over the energy range 0-1keV. Fig. 9 compares the present measurement for the Nc 11 optical excitation cross sections with those of Luyken et al. (1972), van Raan (1973), 1 Dijkkamp and de Heer (198 1) and Eckhardt and Schartner (1983). As seen from the figure, the cross sections from van Raan [(1973) and Luyken et al. (1972,), who used van Raan's measurement at 300 CV to put their cross sections on an absolute scale, arc much higher than other reported measurements. Dijkkamp and de I leer (1981) pointed out that extrapolation of van Raan's (1973) calibration down to 46 nm led to a significant error. The results from Zapesochnyi et al. (1974), which arc not shown in the figure, arc almost twelve times higher than the present measurements. They cal ibrated thci r spectrometer against the data of van Raan (1973). We renormalized the Luyken et al. (1972) results to our cross section at 500 cV. The renormalized cross sections of Luyken et al. (] 972) agree well with the present results especially in the high energy region. our resul ts arc approximately 1.5 to 2 times lower than those of 1 Dijkkamp and dc Heer (198 I) and Eckhardt and Schartner (1 983).

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TABLE 1

ABSOLUTE EYHSS1ON CROSS SECTIONS OF Ne AT 300 eV

Feature	Species	Integrated λ (rim)	Observed Peak λ (nm) Emission	Cross Section ($x10^{-19} cm^2$)
1	Ne II	45.1 - 47.1	46.1	15.3
2	Ne III	**48.5 -49.5**	49.0	**1.85**
3	Ne I	**57.3 -59.5**	58.9	5.67
4	Ne I	59.6 - 60.9	60.1	3.99
5	Ne I	**61.2 -62.3**	61.9	**3.29**
6	Ne I	62.4 -63.5	62.8	8.01
7	Ne I	71.4 - 74.1	73.6	53.2
8	Ne I	7.4.2 -76.2	74.4	12.1

TABLE 2. ABSOLUTE EMISSION CROSS SECTIONS OF NEON RESONANCE TRANSITIONS IN THE EUV ($10^{-18}cm^2$)

ENERGY(eV)	Nc] (73.69 nm)	NcI (74.37 nm)	NeII (46.07 + 46.24 nm)
20	2.55	1.32	
30	6.05	2.31	
40	7.44	2.30	
50	8.18	2.29	
60	8.56	2.28	0.20
70	8.71	2.?6	0.37
80	8.70	2.22	0.55
90	8.59	2..15	0.71
100	8.42	2.08	0.86
125	7.92	1.90	1.16
150	7.41	1.74	1.35
175	6.9S	1.61	1.47
2.00	6.55	1,51	1.53
2s0	5.86	1.34	1.56
300	5.27	1.21	1.s2
350	4.76	1.10	1.51
400	4.30	0.99	1.46

Figure Captions

Fig. 1: A simplified level diagram for the prominent transitions of Ne and Ne 11 is shown. At the left-hand side, the electron configuration with terms and levels are indicated for Ne 1 and Ne 11. At the right-hand side, the terms are given in Paschen notation for Ne I.

Fig. 2 :The intensity ratio of the Ne I resonance line at **73.6** nm and the Ne II ion multiplet at 46.14 nm as a function of Ne gas pressure. The ratio is approximately constant up to about *2. x* 10^{-6} Torr and starts decreasing, indicating the onset of self-absorption of Ne 1 resonance line at 73.6 nm. The Ne 11 feature at (46.1 -46.2 nm), which exhibits no optical depth, acts as a normalization feature.

Fig. 3: Calibrated, polarization free electron-impact induced emission spectrum of Ne at 300 eV. The spectrum was obtained in the crossed-beam mode at *5 x 10-7* Torr background gas pressure. Emission cross sections for the identified features (numbered) are listed in Table 1.

Fig. 4: Relative emission cross section (optical excitation function) of the Ne I resonance line at 73.6 nm from 0-400 eV electron-impact energy. The data were corrected for polarization. The appearance potential is at 16.85 eV. Solid line represents a fitting function (Shemansky et al., 1985a, b) to the data.

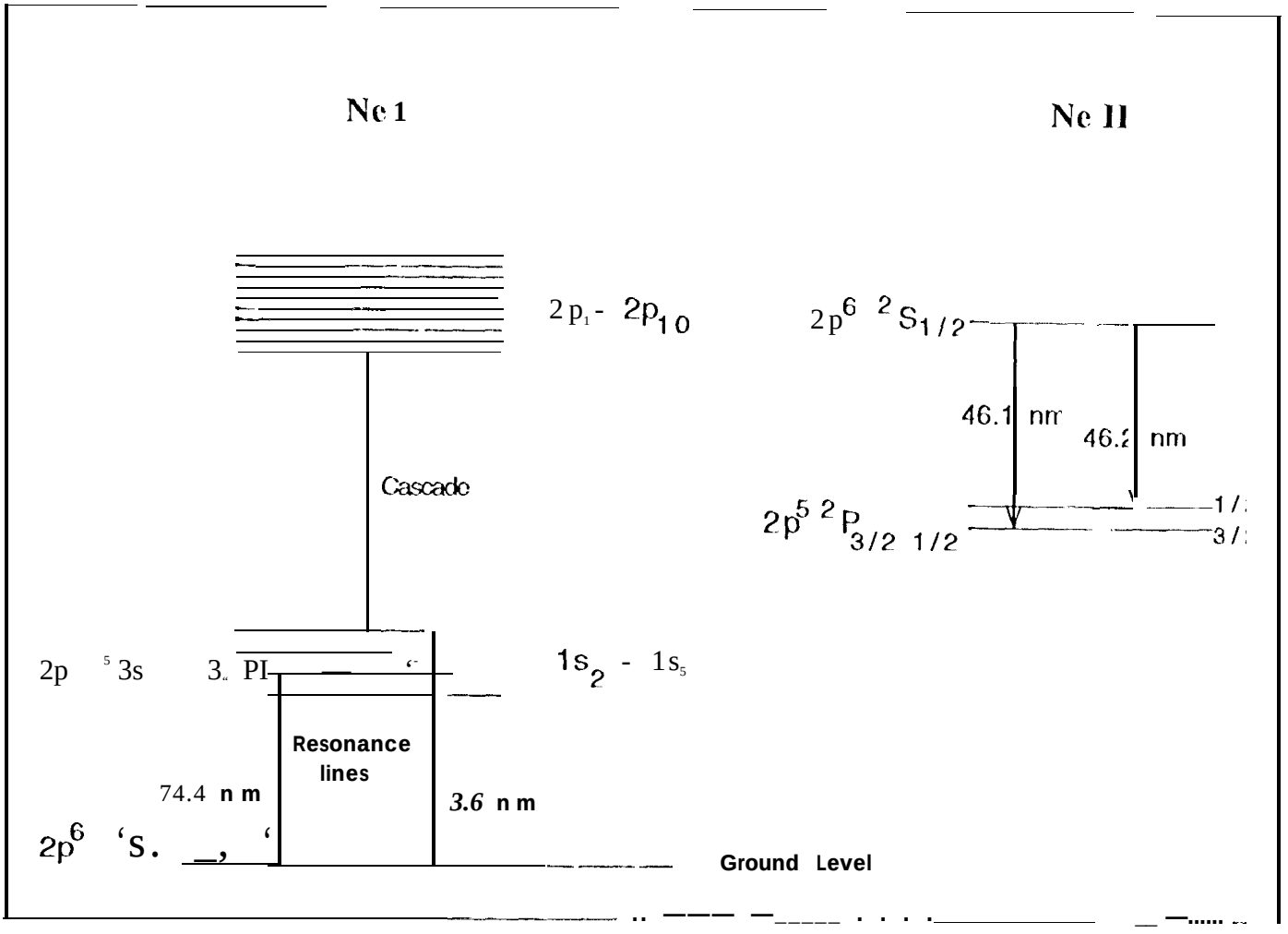
Fig. S : Relative emission cross section (optical excitation function) of the Ne I resonance line at 74.4 nm from 0-400 eV electron-impact energy. The data were corrected for polarization. The appearance potential is at 16,66 eV. Solid line represents a fitting function (Shemansky et al., 1985a, b) to the data.

Fig. 6: Comparison of published data for the cross section Of the Ne 1 resonance line at 73.6 nm in the ()-400 CV energy range. The cross sections arc given in the units of 1()-18 cm^2. Measurements shown arc: solid line, present data (error bars arc also shown); +, Hertz (1969) high-pressure ($2.7x10^{-3}$ '1'err) data; x, Hertz (1969) low-pressure (0.3-0.8 $x10^{-4}$ Torr); A, Tan et al. (1974); O, Phillips et al. (1985); El, de Jongh (197 1); 0, Register et al. (1984).

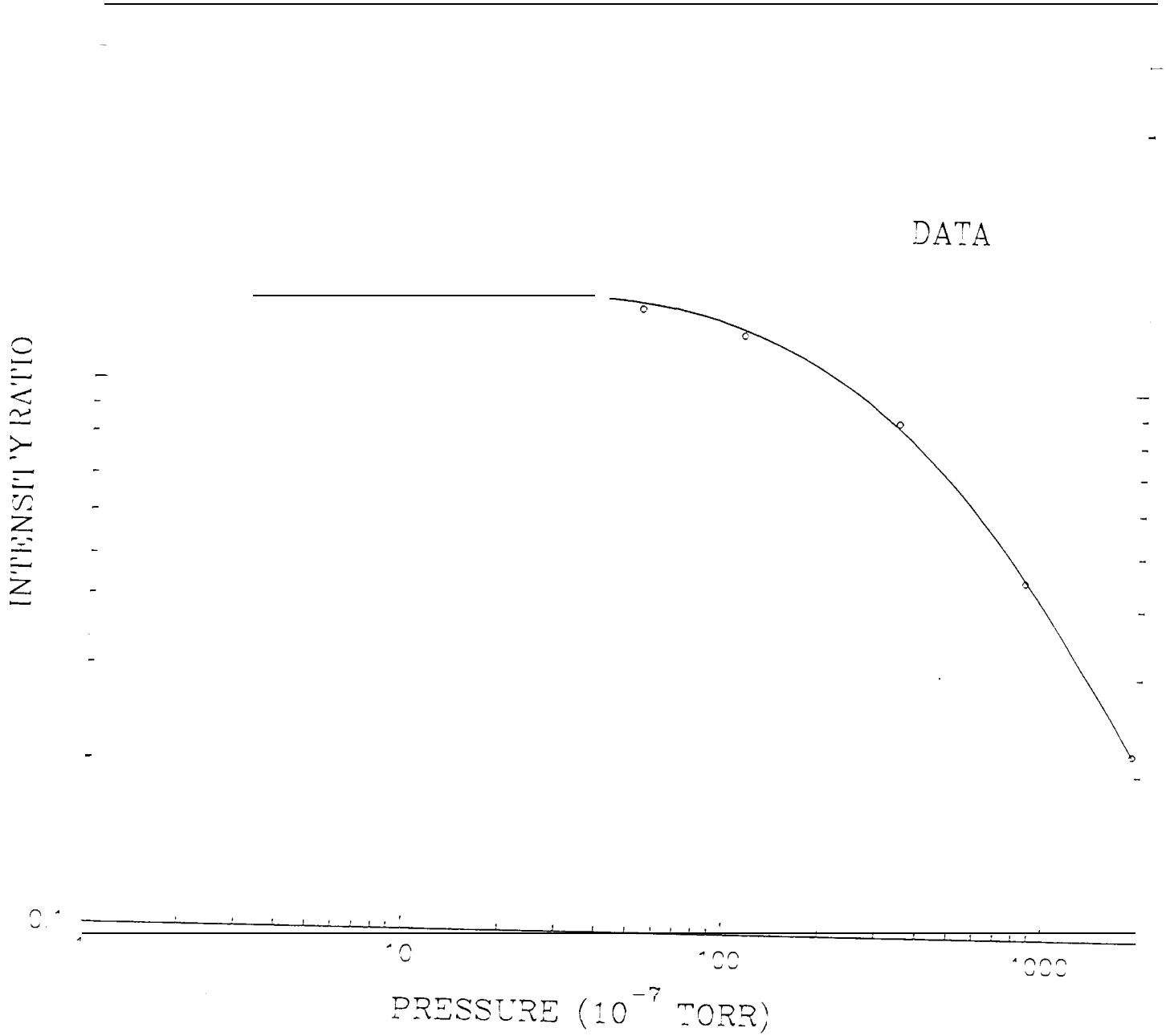
Fig. 7: Comparison of published data for the cross section of the Nc I resonance line at 74.4 nm in the 0-400 eV energy range. The cross sections arc given in the units of 10-18 cm^2. Measurements shown arc: solid line, present data (error bars arc also shown); ❑ , Hertz (1969); ◊, Phillips et al. (1985); -i, Register et al. (1984).

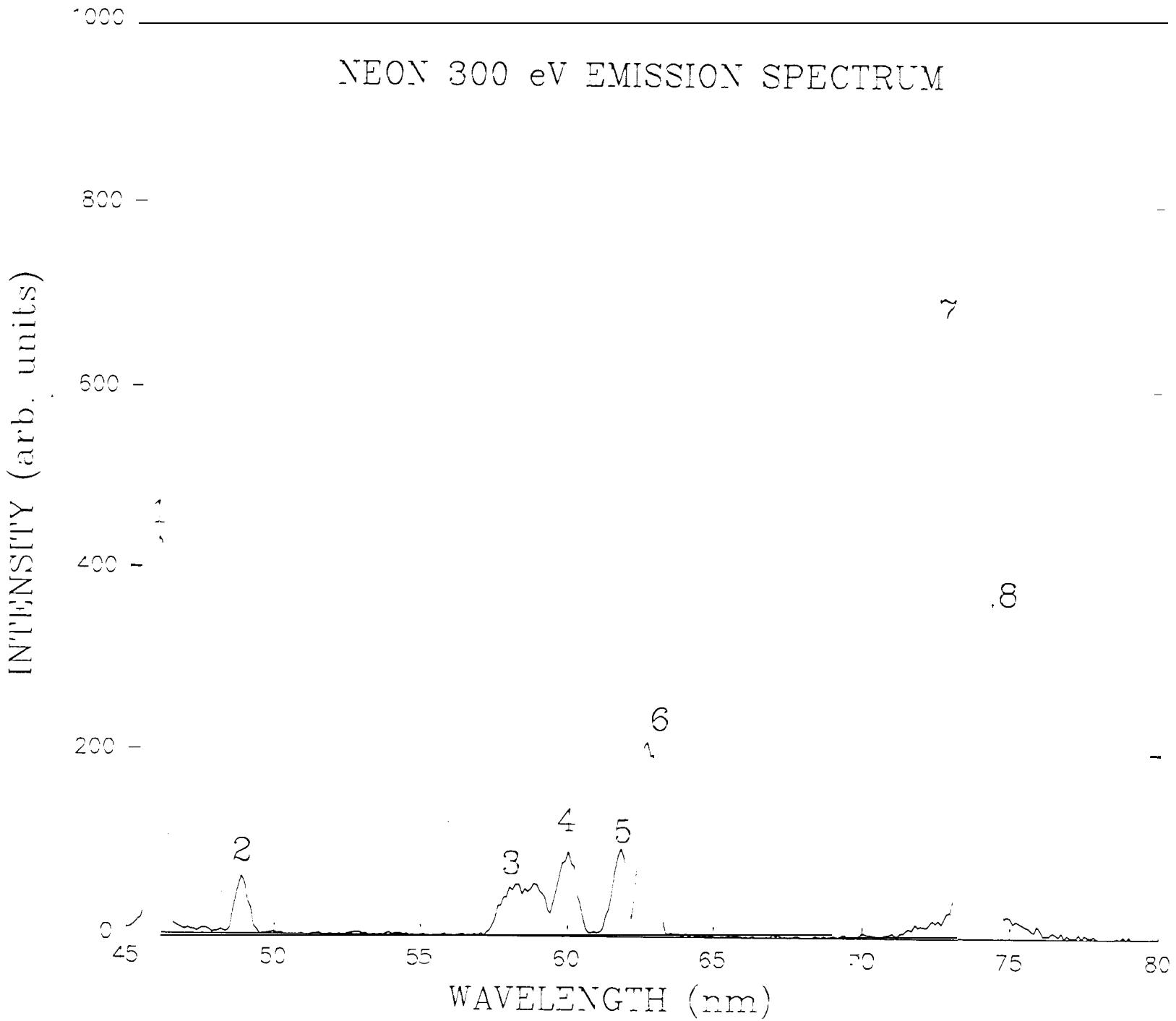
Fig. 8: Relative emission **cross** section **(optical excitation** function) of the Nc 11 ion multiplet at 46.14 nm from O-1 keV electron-impact energy. The appearance potential is at 48.43 cV. Solid line represents a fitting function (Shemansky et al., 1985a, b) to the data.

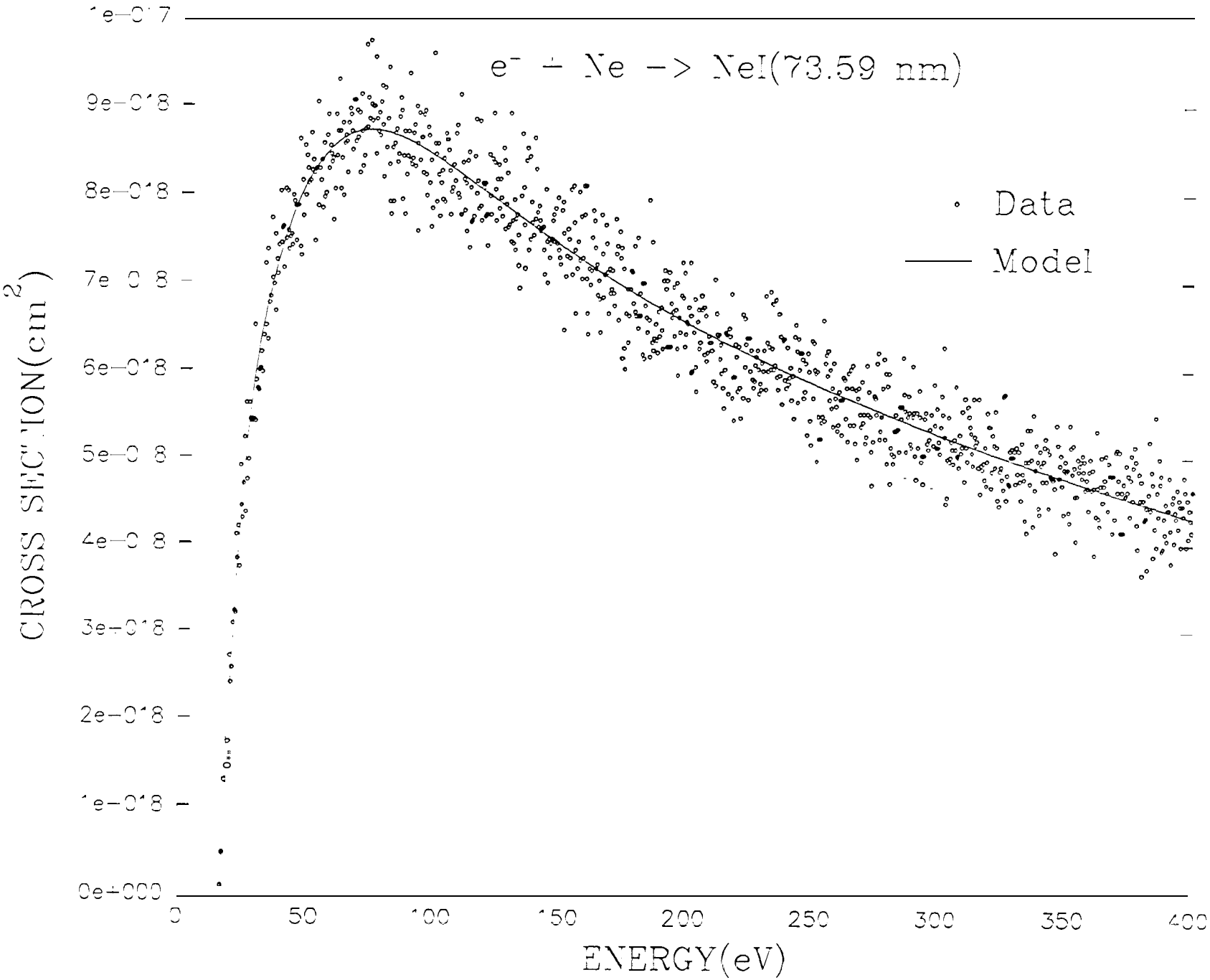
Fig. 9: Comparison of published data for the cross section of the combined Nc] I ion multiplet at 46.14 nm in the 1 keV energy range. The cross sections arc given in the units of 10-18 cm^2. Measurements shown arc: solid line, present data (error bars arc also shown); □, Luyken et al. (1972); C), Luyken et al. (1972) normalized to present data at 500 cV; O, Dijkkamp and de Heer (198 1); +, Eckhardt and Schartner (1 983); x, van Raan (1973).

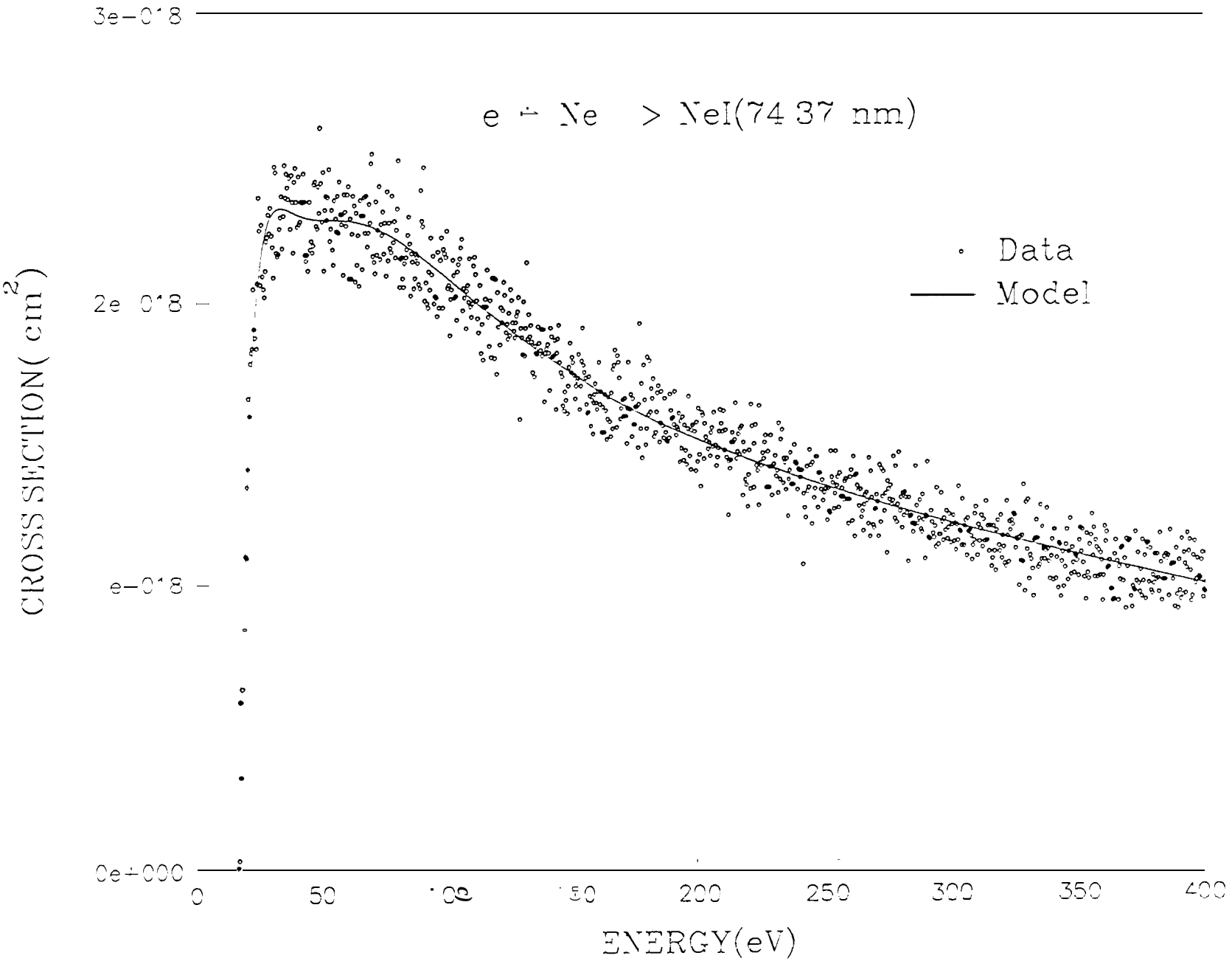


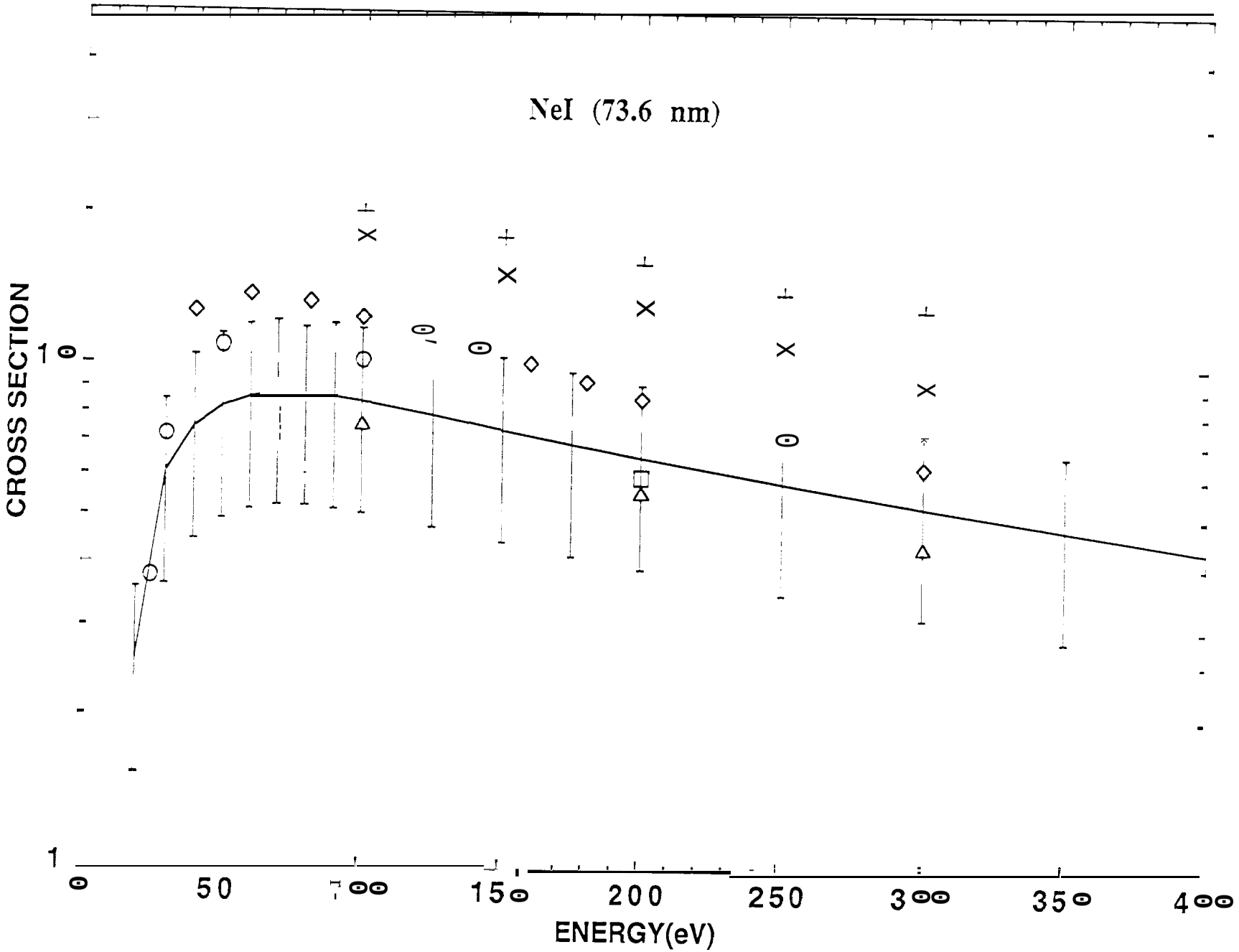
Ne 1
Ne II
2p1 - 2p10
2p6 2S1/2
46.1 nm
46.2 nm
Cascade
2p5 2P3/2 1/2
1s2 - 1s5
Resonance lines
74.4 nm
3.6 nm
2p6 'S.
Ground Level

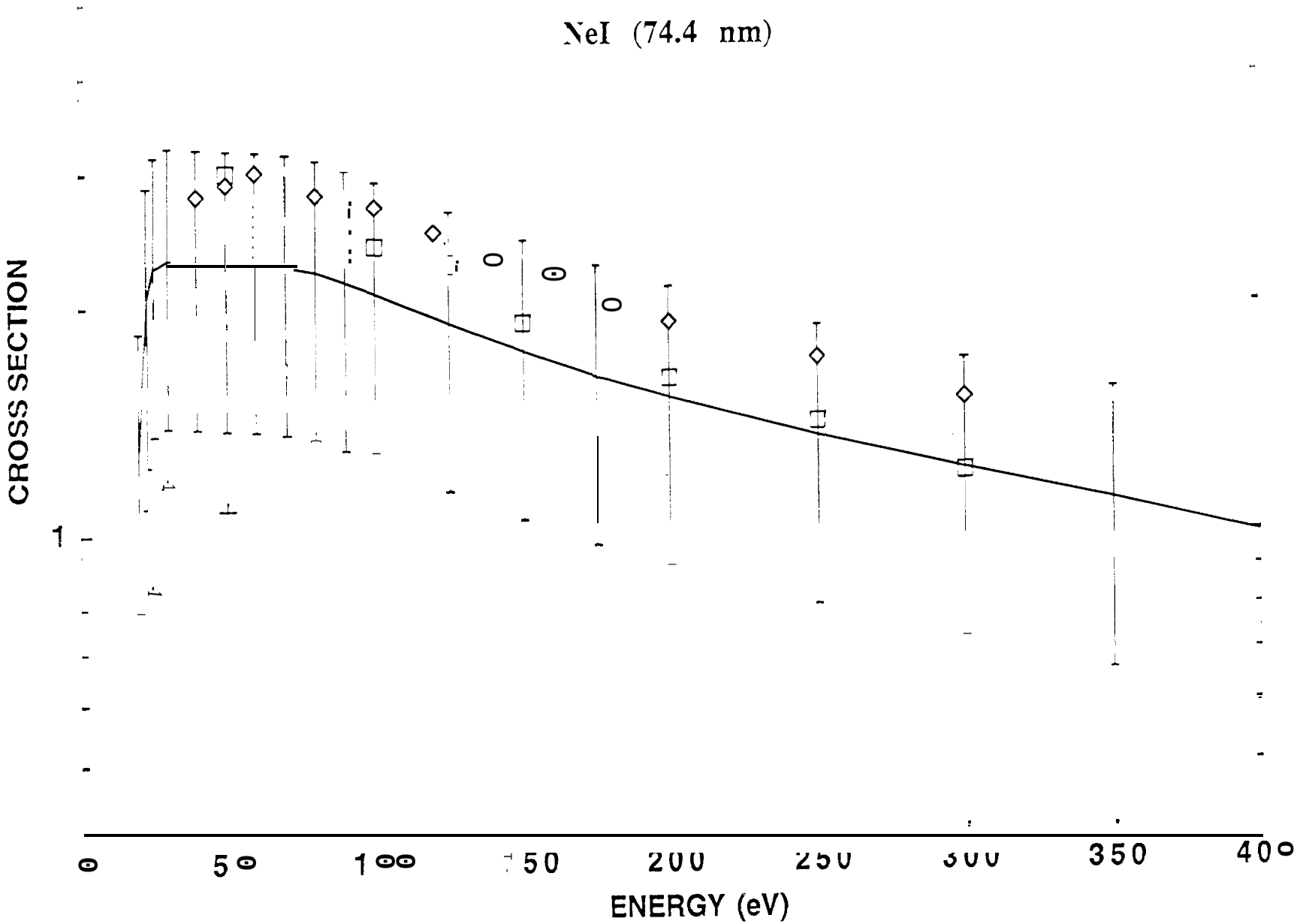

DATA
INTENSITY RATIO
0.1
10
100
1000
PRESSURE (10^{-7} TORR)

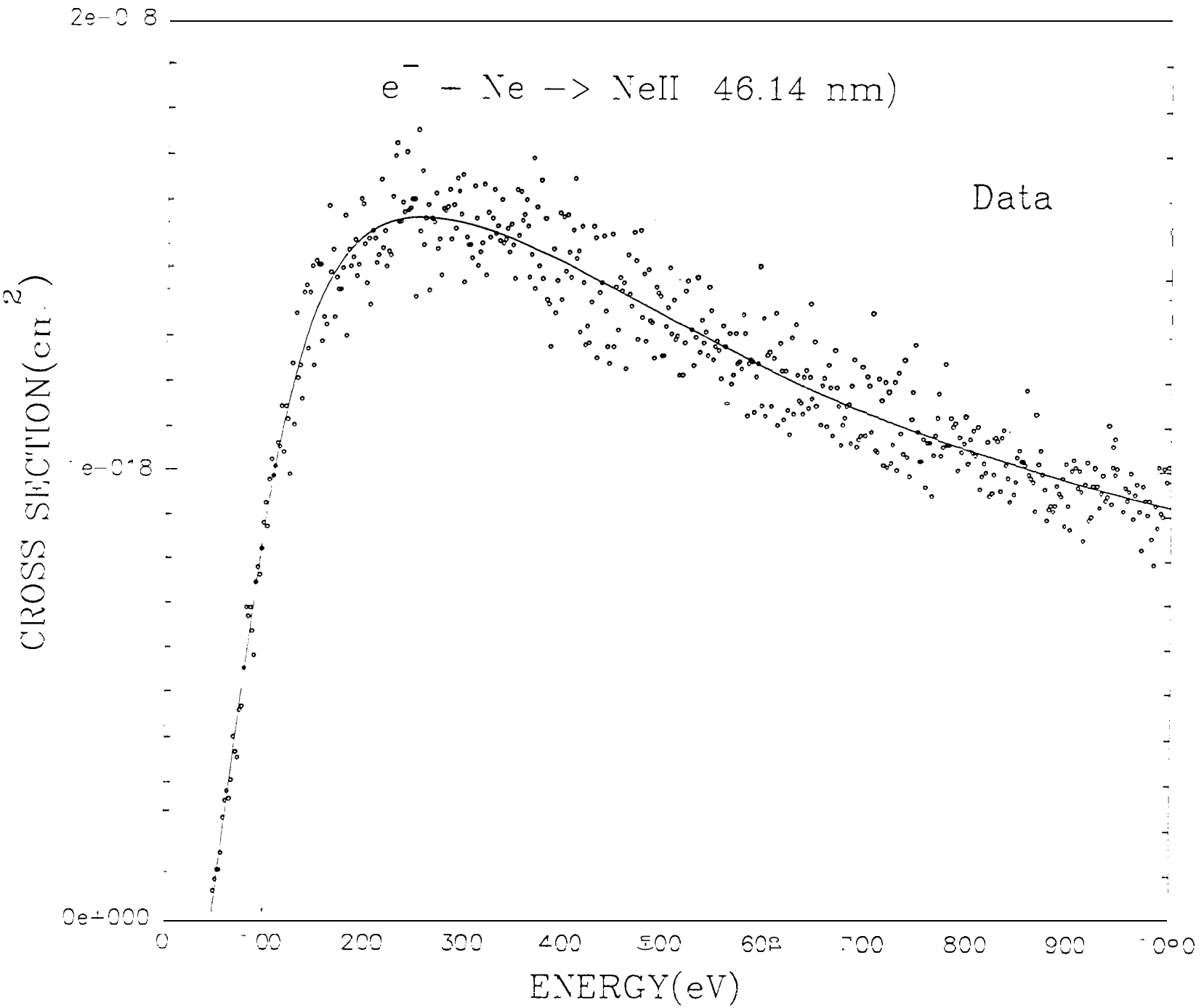

NEON 300 eV EMISSION SPECTRUM
INTENSITY (arb. units)
800
600
400
200
0
45
50
55
60
65
70
75
80
WAVELENGTH (nm)
2
3
4
5
6
7
8

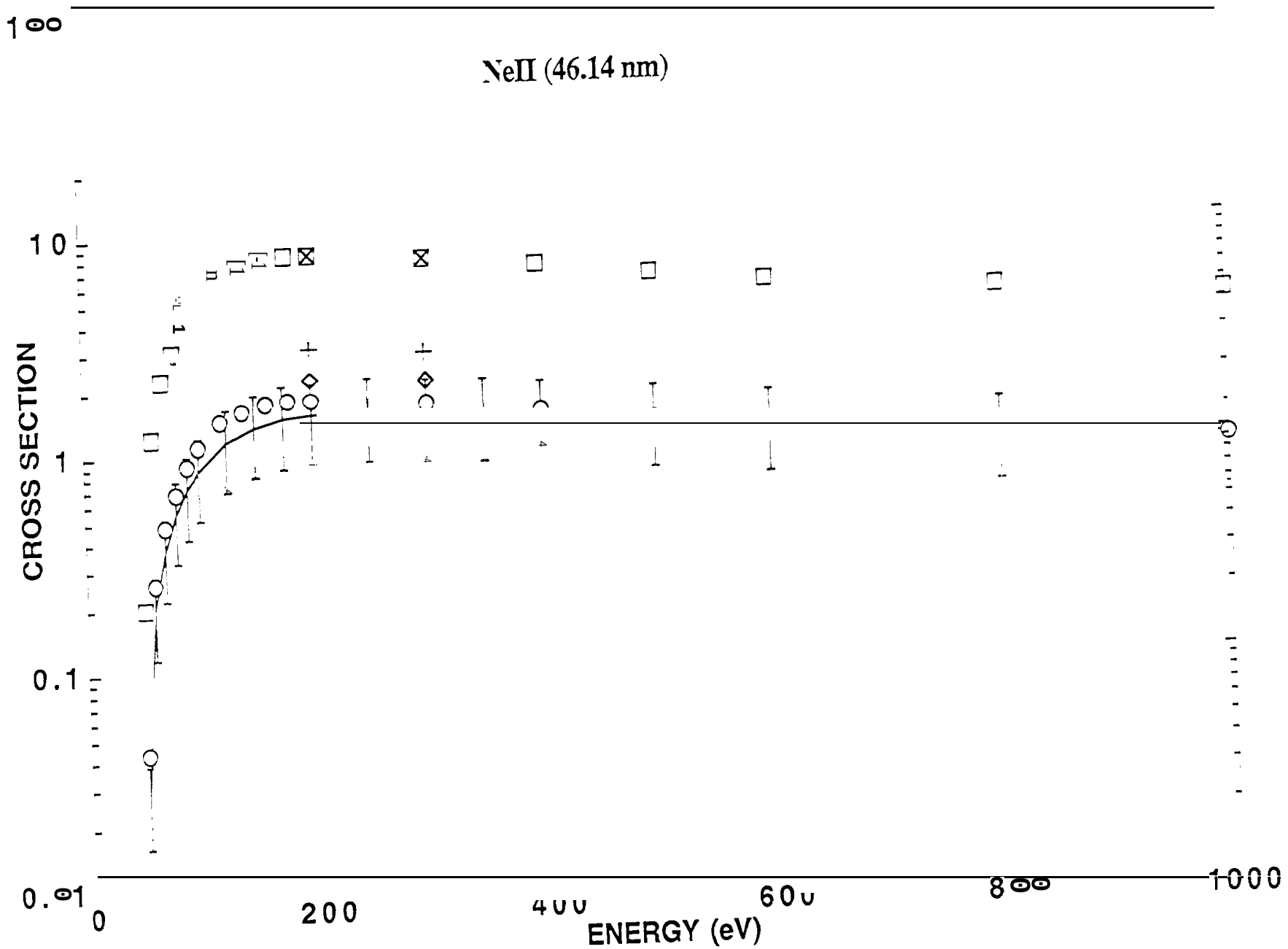

e⁻ + Ne -> NeI(73.59 nm)
Data
Model
CROSS SECTION(cm²)
ENERGY(eV)
0e+000
2e-018
3e-018
4e-018
5e-018
6e-018
7e-018
8e-018
9e-018
0
50
100
150
200
250
300
350
400


e + Ne > NeI(74.37 nm)
Data
Model
CROSS SECTION(cm^2)
3e-018
2e-018
1e-018
0e+000
0
50
100
150
200
250
300
350
400
ENERGY(eV)


NeI (73.6 nm)
CROSS SECTION
1
0
1
0
50
100
150
200
250
300
350
400
ENERGY(eV)


NeI (74.4 nm)
CROSS SECTION
1
0
50
100
150
200
250
300
350
400
ENERGY (eV)


e⁻ – Ne –> NeII 46.14 nm)
Data
CROSS SECTION(cm²)
2e-0 8
e-0 8
0e+000
0
200
300
400
500
600
700
800
900
ENERGY(eV)


NeII (46.14 nm)
CROSS SECTION
ENERGY (eV)
100
10
1
0.1
0.01
0
200
400
600
800
1000